PRODUCTION ENGINEERING MEASURE
FUNDAMENTAL MODE CRYSTAL FOR FILTERS

CR(XM-41)/U

CONTRACT NO. DA-36-039-SC-85956
ORDER NO. 6011-PP-61-81-81

SIXTH QUARTERLY REPORT

AUGUST 10, 1962 TO DECEMBER 9, 1962

PREPARED FOR
U. S. ARMY ELECTRONICS MATERIEL AGENCY
PHILADELPHIA, PENNA.

BY

PIEZO CRYSTAL COMPANY
CARLISLE, PENNA.

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PURPOSE

DEVELOP AND PRODUCE 500 UNITS ON FREQUENCIES 10 MC, 11.5 MC, 15.0 MC, 20.0 MC AND 30.0 MC USING BOTH NATURAL AND CULTURED QUARTZ IN ACCORDANCE WITH SIGNAL CORPS TECHNICAL REQUIREMENT SCS-76A DATED 20 JANUARY 1960.

ABSTRACT

DURING THE PROCESSING AND TESTING OF THE 30 MC FILTER TYPE CRYSTALS, ABOUT 60% OF THE CULTURED QUARTZ UNITS WERE GOING OUT OF FREQUENCY TOLERANCE DURING THE TEMPERATURE TEST. UNITS OF NATURAL QUARTZ MANUFACTURED ALONG WITH CULTURED QUARTZ REMAINED IN TOLERANCES DURING THE TEMPERATURE RUN. INVESTIGATION REVEALED THAT CULTURED QUARTZ DOES NOT HAVE THE SAME TEMPERATURE COEFFICIENT AFTER GRINDING DUE TO OUR APPARENT ANGULAR SHIFT WHEN CRYSTALS HAVE A LARGE AMOUNT OF QUARTZ REMOVED BY GRINDING. A FINAL DESIGN FOR FILTER BLANKS WAS DERIVED AND THE PREPRODUCTION SAMPLES WERE SUBMITTED FOR TEST.

NARRATIVE

IN OUR PREVIOUS REPORT, THE FIFTH QUARTERLY REPORT, WE HAD MENTIONED THAT ABOUT 60% OF OUR HIGH FREQUENCY 30 MC FILTER CRYSTALS IN CULTURED QUARTZ WERE GOING OUT OF FREQUENCY TOLERANCE IN TEMPERATURE TESTING. WE HAD SELECTED THE ZZ' ANGLE 35° 15' FOR BOTH CULTURED AND NATURAL QUARTZ. THE ANGLE WAS MEASURED WHILE THE BLANKS WERE IN THE SQUARE STAGE AND AT 4 MC BEFORE MUCH QUARTZ REMOVAL. FROM THIS POINT THEY WERE ROUNDED TO .250" DIAMETER AND GROUND TO NEAR THE FINISHED FREQUENCY. THERE WAS NO FURTHER X-RAY MEASUREMENTS DUE TO THE SIZE AND THICKNESS OR (THINNESS) OF THE BLANKS AT 30 MEGACYCLES. WHEN THE BLANKS WERE TESTED A LARGE PERCENTAGE OF THE CULTURED QUARTZ UNITS HAD TOO GREAT A DRIFT OVER THE TEMPERATURE RANGE. THE UNITS IN NATURAL QUARTZ OF THE SAME 35° 15' ZZ' ANGLE PASSED THROUGH THE TEMPERATURE RANGE WITHIN THE TOLERANCES. FURTHER INVESTIGATION OF 20 MEGACYCLE CRYSTALS X-RAY SORTED IN THE SAME MANNER REVEALED THAT THE CULTURED UNITS WERE CLOSE TO GOING OUT OF TOLERANCE ALSO. THE 10 MEGACYCLE CRYSTALS X-RAY SORTED IN THE SAME SQUARE STAGE IN BOTH CULTURED AND NATURAL QUARTZ WERE WITHIN TOLERANCE WHEN TESTED OVER THE TEMPERATURE RANGE. AFTER SEVERAL TESTS ON THE 30 MC AND 10 MC CRYSTALS IN CULTURED AND NATURAL QUARTZ IT WAS FOUND THAT THE CULTURED UNITS AT 30 MEGACYCLE WERE CONSISTENTLY SHOWING A GREATER DRIFT OVER THE TEMPERATURE RANGE.

THE 10 MC CRYSTALS WERE CONSISTENTLY WITHIN THE TOLERANCE LEVELS. THERE IS AN APPARENT ZZ' CHANGE WITH GRINDING. THE 30 MC CRYSTALS HAVING THE GREATEST AMOUNT OF QUARTZ REMOVAL SHOW A GREATER DEVIATION FROM THE ORIGINAL ANGLE MEASUREMENT. WE FINALLY SETTLED ON A SLIGHTLY HIGHER ZZ' OF 35° 17' ±3' FOR BOTH THE NATURAL AND CULTURED QUARTZ ON ALL FREQUENCIES ON THE CONTRACT. TEMPERATURE TESTS WITH THIS NEW ANGLE ADJUSTMENT SHOW THAT WE WILL BE SAFELY WITHIN THE TOLERANCE ON ALL FREQUENCIES IN EITHER CULTURED OR NATURAL QUARTZ. SAWYER'S CULTURED QUARTZ WAS USED FOR ALL OUR EXPERIMENTS SINCE WE HAD A LARGE ENOUGH QUANTITY OF IT ON HAND TO PRODUCE UNITS FOR TESTING AND MAKING THE PILOT RUNS. CULTURED QUARTZ SUPPLIED BY OTHER VENDORS WAS PROCESSED INTO 10 MC UNITS AND TEMPERATURE TESTED. ALL BLANKS WERE SELECTED FROM THE X-RAY SORT AT 35° 19' ±1'. WE HAD A NUMBER OF BLANKS CUT FROM SEVERAL VENDORS CULTURED BARS ON HAND AT THE ABOVE ANGLE AND FELT THIS WOULD BE CLOSE ENOUGH TO MAKE A COMPARISON TEST. THE TEMPERATURE TESTS REVEALED THAT THE TEMPERATURE COEFFICIENT OF THE CRYSTALS VARIED FROM ONE TYPE OF QUARTZ TO ANOTHER. TO COMPENSATE FOR THIS VARIATION AN ANGLE ADJUSTMENT OF 5' OF ARC WOULD BE NEEDED. THERE WAS NO SIGNIFICANT DIFFERENCE IN THE SPURIOUS RESPONSES FROM THE CULTURED QUARTZ OF THE VARIOUS SUPPLIERS.

ON PAGE 6 WE HAVE SHOWN AVERAGE CURVES OF THE 10 MC CRYSTALS PROCESSED FROM THE CULTURED QUARTZ SUPPLIED BY THE VENDORS ALONG WITH ONE IN NATURAL QUARTZ. THE PRE-PRODUCTION SAMPLES WERE SUBMITTED OCTOBER 30, 1962 TO VICTOR ELECTRONICS FOR TESTING TO THE SPECIFICATION OF SCA-76A ON OUR CONTRACT. IMMEDIATELY AFTER SUBMITTING THE SAMPLES WE TURNED TO MAKING A PILOT RUN OF 100 CRYSTALS AT 10 MC ON BOTH CULTURED AND NATURAL QUARTZ. OUR AIM WAS TO SEE HOW WELL WE COULD REPEAT OUR PROCESSING TECHNIQUES IN PRODUCTION QUANTITIES.

THE FINAL DESIGN OF THE BLANKS WAS AS FOLLOWS:

SPECIFICATIONS FOR 10 MC FILTER BLANKS

SIZE .300" DIAMETER

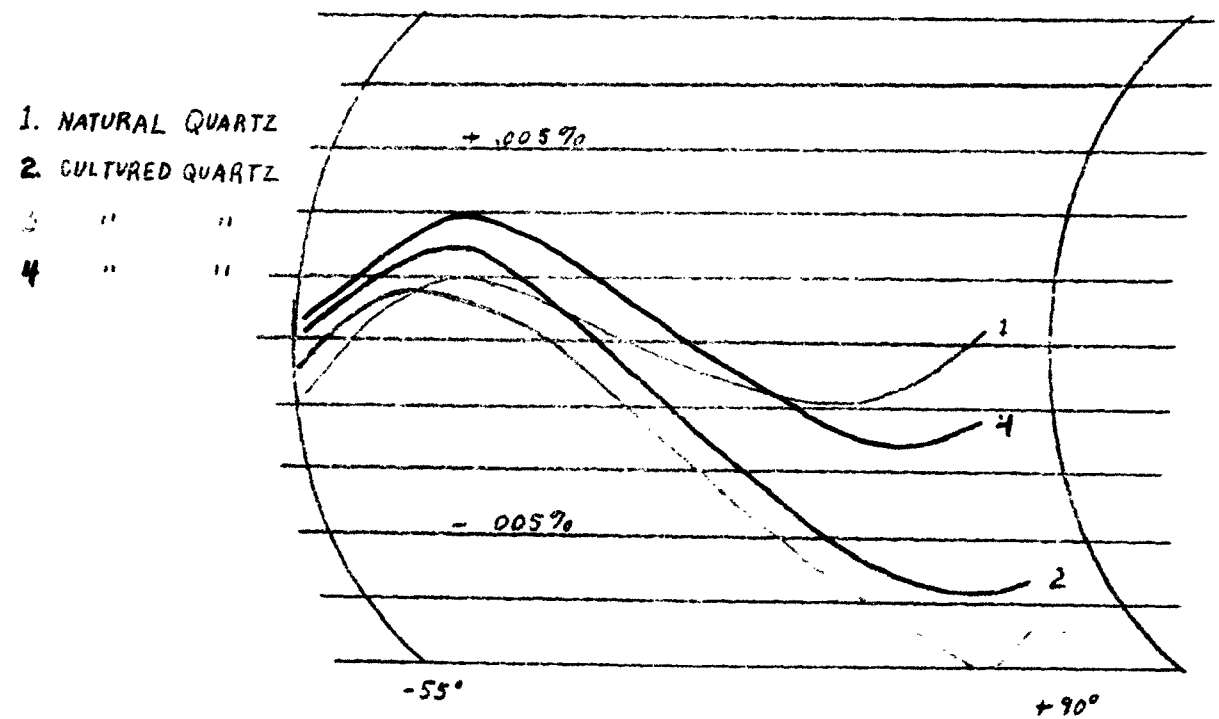
ZZ' ANGLE 35° 17' ±3'

FINISH GRIND IN 304 EMERY TO 10.050 MC

ELECTRODE SIZE .105" DIAMETER EVAPORATED SILVER

ELECTROPLATE WITH NICKEL TO FREQUENCY.

THE FIRST CRYSTALS TO GET TO THE FINISHING WERE RUNNING HIGH IN RESISTANCE AND ABOUT 20% WERE OVER THE 100 OHMS MAXIMUM. THE HIGH RESISTANCE WAS CAUSED BY PITS OR BUBBLES NEAR THE SURFACE OF THE BLANKS..



TEMP CURVES ON CULTURED AND NATURAL QUARTZ AT .10 MC

AVERAGE TEMP. CURVES OF CULTURED QUARTZ FROM 3 VENDORS COMPARED WITH NATURAL QUARTZ ZZ' ANGLE FOR ALL TYPES 35° 19'.

THESE BLANKS WERE ELIMINATED AND NEW BLANKS PROCESSED TO REPLACE THEM. AFTER COMPLETING THE FINISHING TO FREQUENCY ON THE GROUP THE LOSS DUE TO RESISTANCE WAS ONLY 5 UNITS AT THIS TIME. ON PAGES 8-10 WE HAVE CHARTS SHOWING THE EFFECTS OF SHOCK, VIBRATION AND AGING ON A REPRESENTATIVE GROUP OF THE 10 MC CRYSTALS. THE CRYSTALS PASSED ALL THE OTHER REQUIREMENTS ON SCA76A. THE CRYSTALS WERE THEN SCANNED FOR SPURIOUS RESPONSES WITHIN THE ±5% OF NOMINAL FREQUENCY. WE HAVE INCLUDED 3 CHARTS ON PAGES 11-13 WHICH CAN BE CONSIDERED AS REPRESENTATIVE OF THE GROUP. SINCE WE WERE SUCCESSFUL IN RUNNING THE 10 MC CRYSTALS ANOTHER GROUP ON THE N NEXT FREQUENCY 11.5 MC WAS STARTED THRU THE PROCESSING LINE. THE DESIGN OF THIS BLANK IS THE SAME AS THE 10 MC CRYSTAL WITH THE EXCEPTION OF FREQUENCY AND ELECTRODE SIZE.

SPECIFICATION FOR 11.5 MC CRYSTAL BLANKS

SIZE .300" DIAMETER

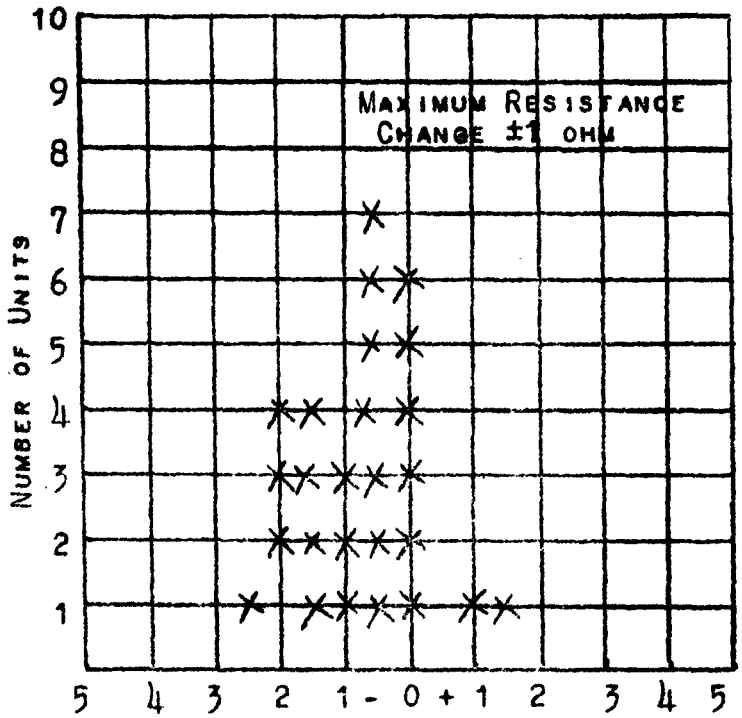
FINISH GRIND IN 304 EMERY TO 11.560 MC

ZZ' ANGLE 35° 17' ±3'

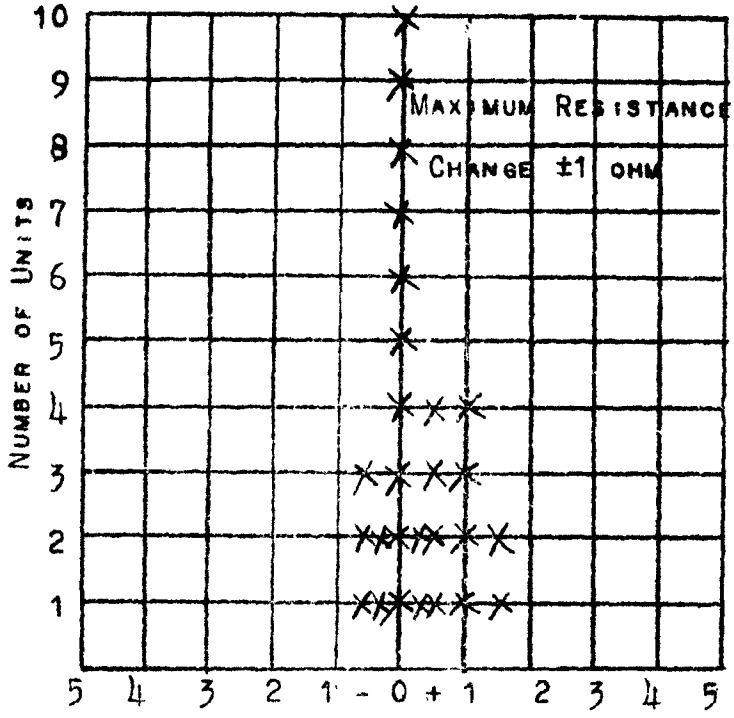
ELECTRODE SIZE .093" DIAMETER EVAPORATED SILVER

ELECTROPLATE TO FREQUENCY WITH NICKEL

10 MC FILTER CRYSTALS
SHOCK TEST

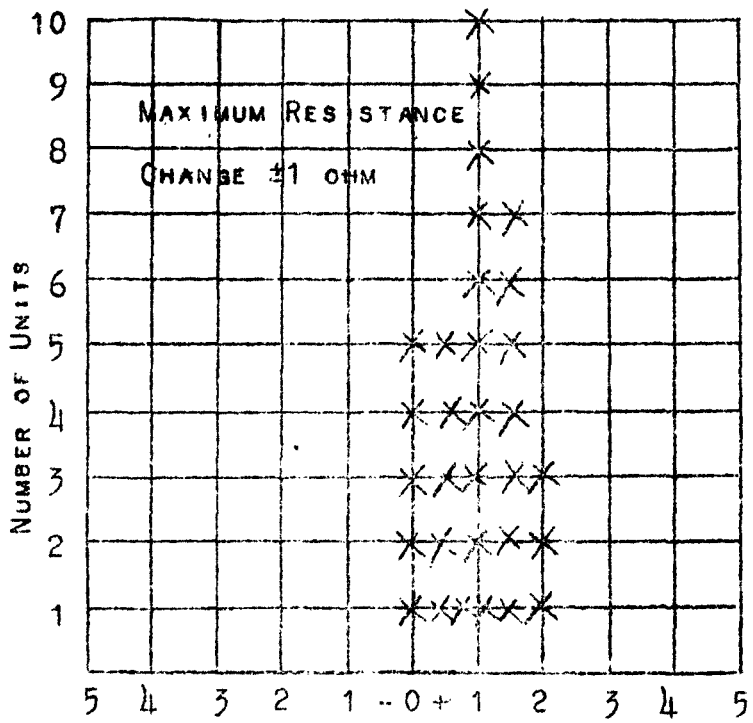


10 MC FILTER CRYSTALS
VIBRATION TEST



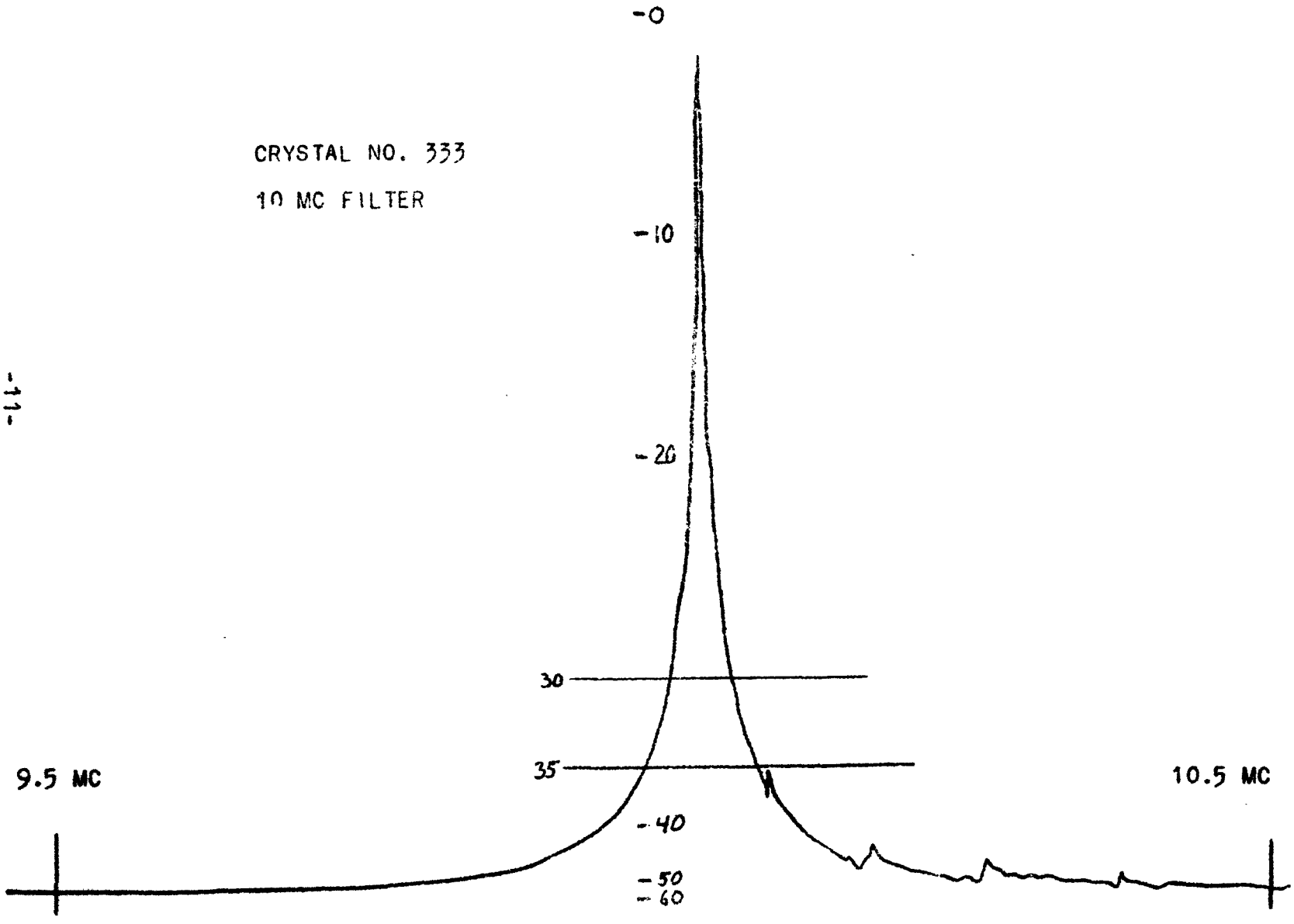
PPM CHANGE
DUE TO
VIBRATION

10 MC FILTER CRYSTALS
AGING TEST



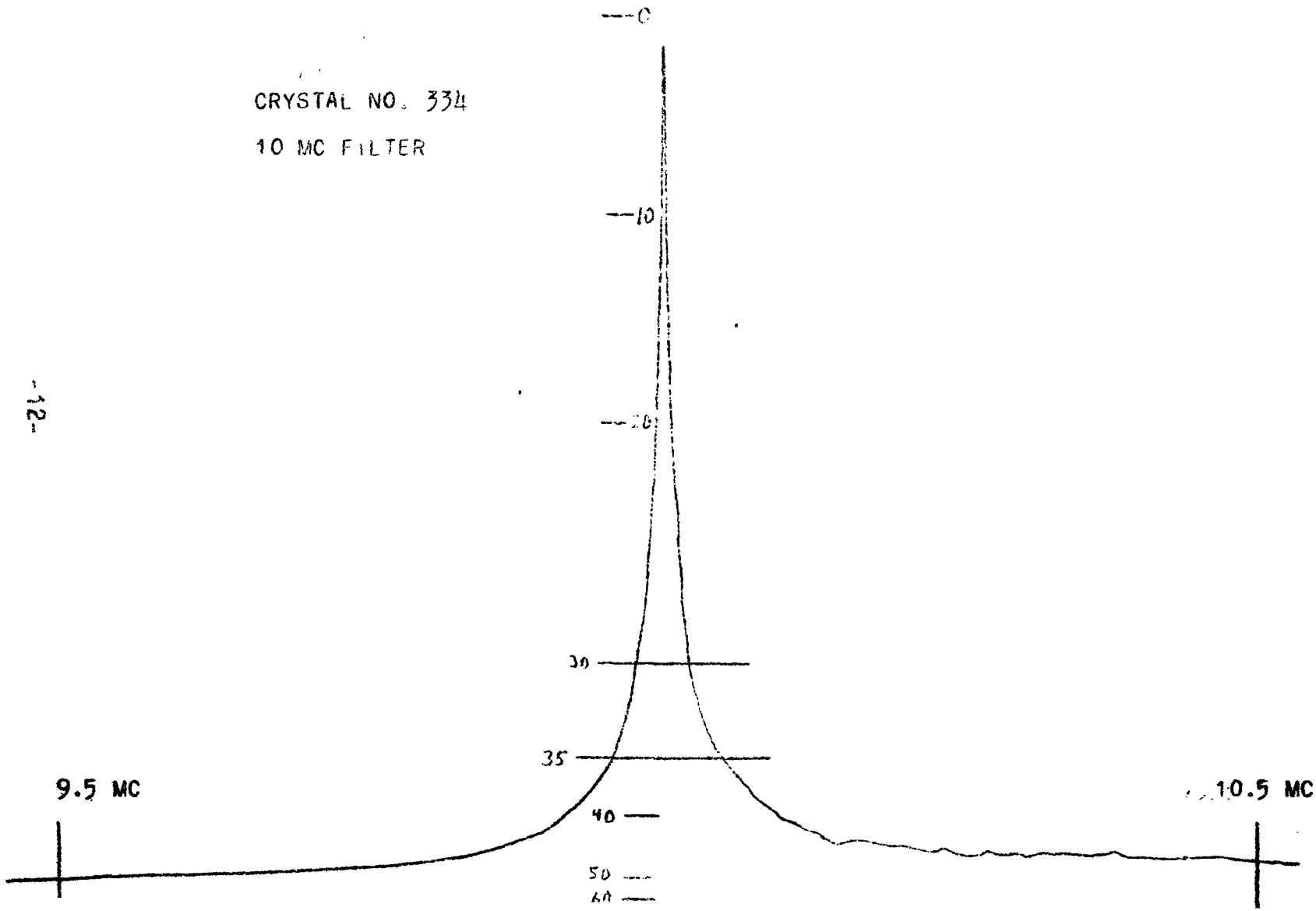
CRYSTAL NO. 333

10 MC FILTER



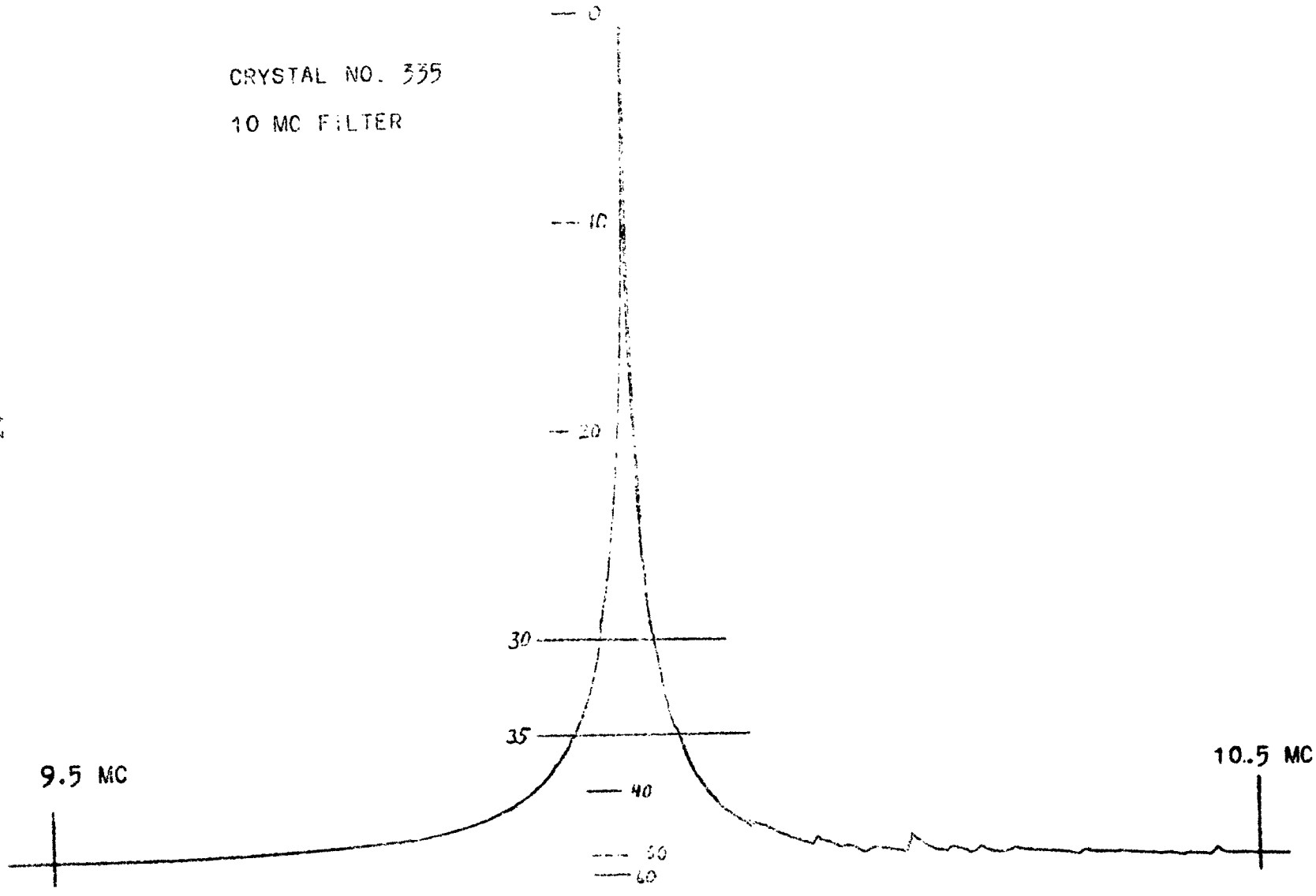
CRYSTAL NO. 334

10 MC FILTER



CRYSTAL NO. 335

10 MC FILTER



THESE CRYSTALS PASSED ALL THE SCA-76A REQUIREMENTS WITH ABOUT ABOUT 2% REJECTED OR MARGINAL. ON PAGES 16-18 ARE 3 REPRESENTATIVE CHARTS SHOWING THE SPURIOUS LEVELS OVER THE FREQUENCY RANGE ±5% OF NOMINAL FREQUENCY. SMALL PRODUCTION GROUPS OF FILTER CRYSTALS WERE PROCESSED ON 15 MC, 20 MC AND 30 MC. THE TECHNIQUES USED WERE AS OUTLINED PREVIOUSLY IN PRODUCING OUR SAMPLE CRYSTAL. RATHER THAN MAKE A LOT OF REPETETIVE STATEMENTS IT WILL SUFFICE TO SAY THAT ALL CRYSTAL WERE PROCESSED IN THE SAME MANNER EXCEPT FOR SIZE AND THICKNESS. ON PAGE 15 THE VARIOUS PARAMETERS FOR THE 15 TO 30 MC CRYSTALS ARE LISTED, AND ON PAGES 19-24 ARE CHARTS RUN TO SHOW SPURIOUS RESPONSES.

SPECIFICATION FOR 15 MC CRYSTAL BLANKS

SIZE .300" DIAMETER

ZZ' ANGLE 35° 17' ±3'

FINISH GRIND IN 304 EMERY TO 15.090 MC

ELECTRODE SIZE .070" DIAMETER EVAPORATED SILVER

ELECTROPLATE WITH NICKEL TO FREQUENCY

SPECIFICATIONS FOR 20 MC CRYSTAL BLANKS

SIZE .250" DIAMETER

ZZ' ANGLE 35° 17' ±3'

FINISH GRIND IN 304 EMERY TO 20.160 MC

ELECTRODE SIZE .052" DIAMETER EVAPORATED SILVER

ELECTROPLATE WITH NICKEL TO FREQUENCY.

SPECIFICATIONS FOR 30 MC CRYSTAL BLANKS

SIZE .250" DIAMETER

ZZ' ANGLE 35° 17' ±3'

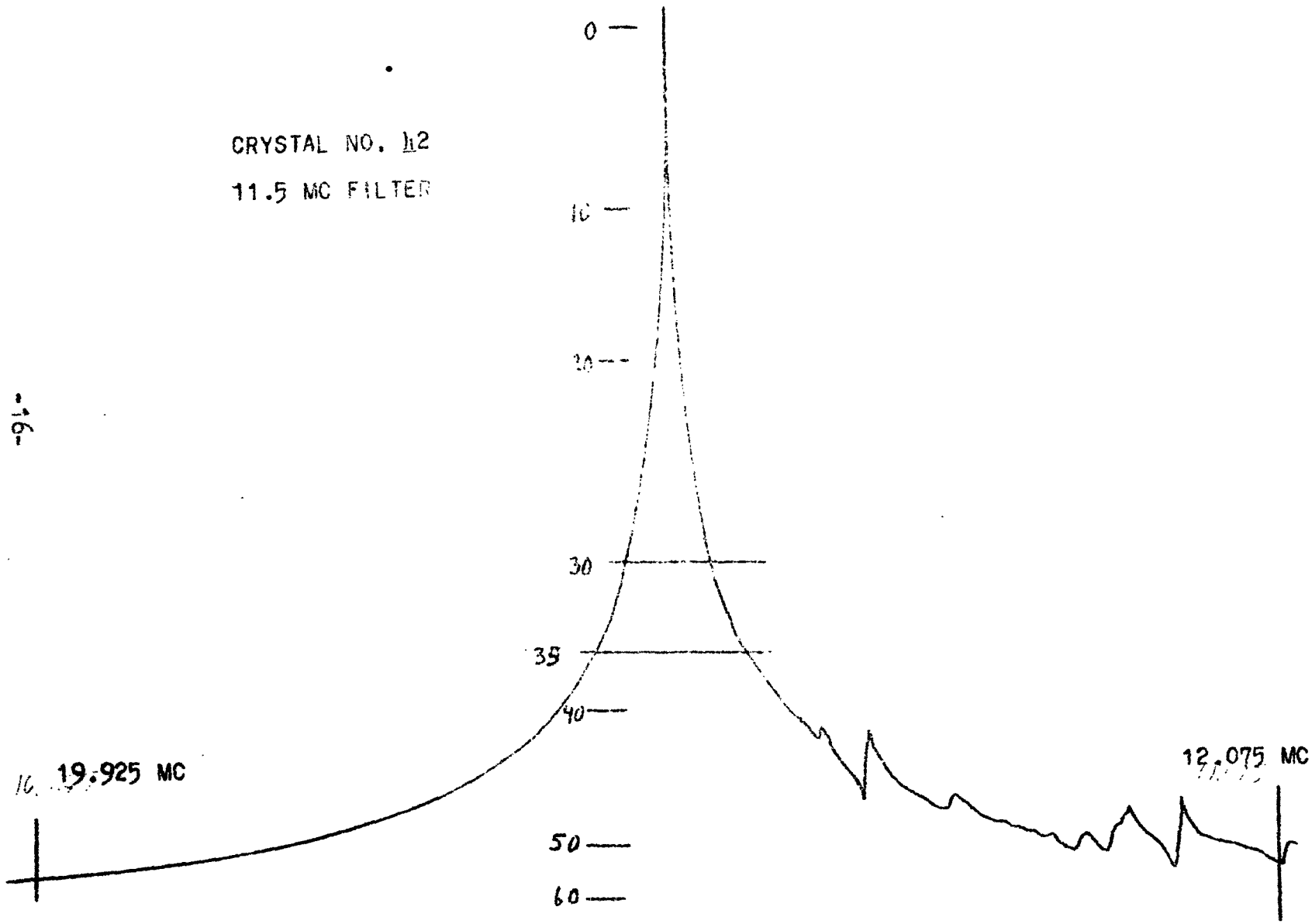
FINISH GRIND WITH 304 TO 30.450 MC

ELECTRODE SIZE .035" DIAMETER EVAPORATED SILVER

ELECTROPLATE WITH NICKEL TO FREQUENCY

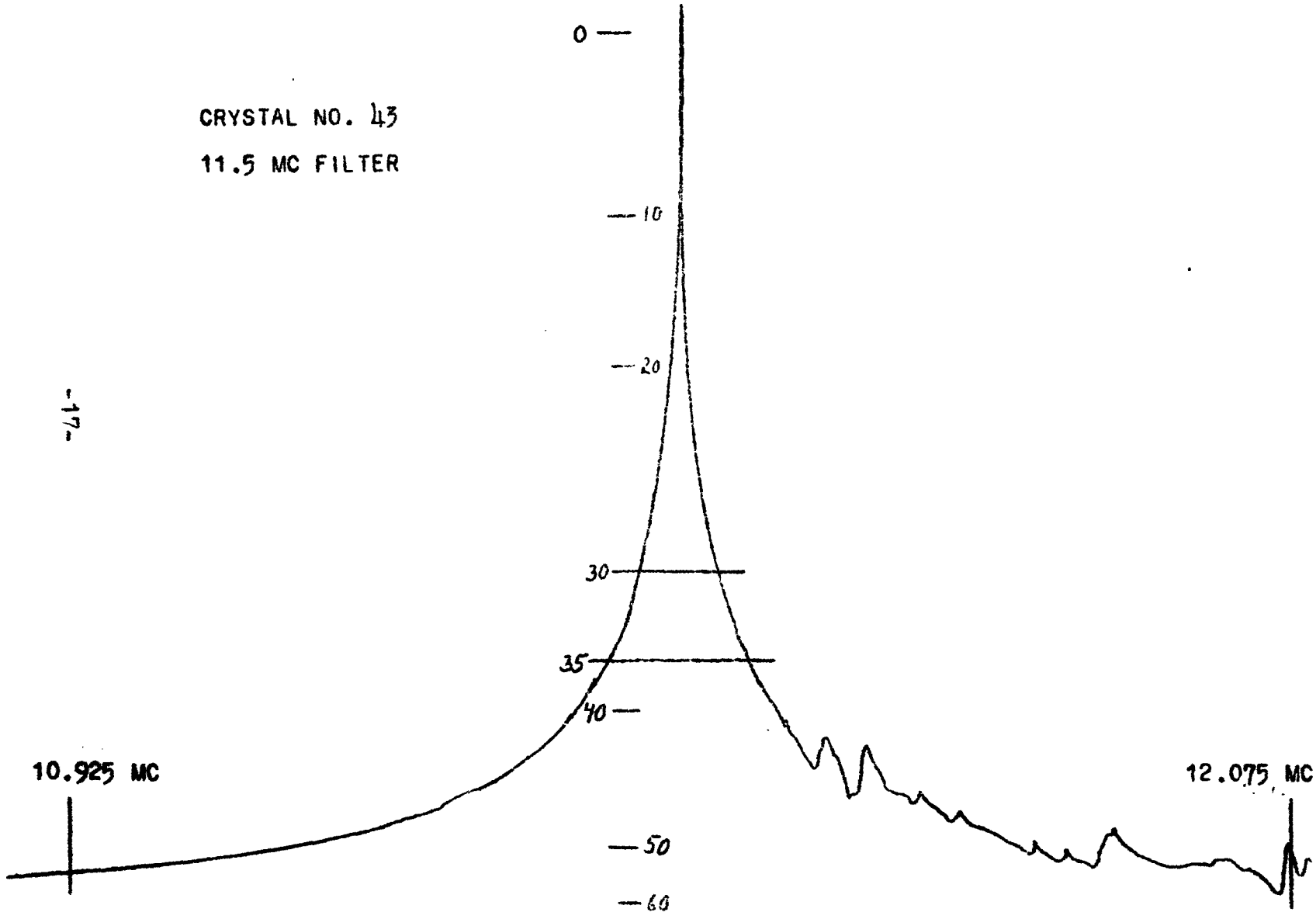
CRYSTAL NO. h2

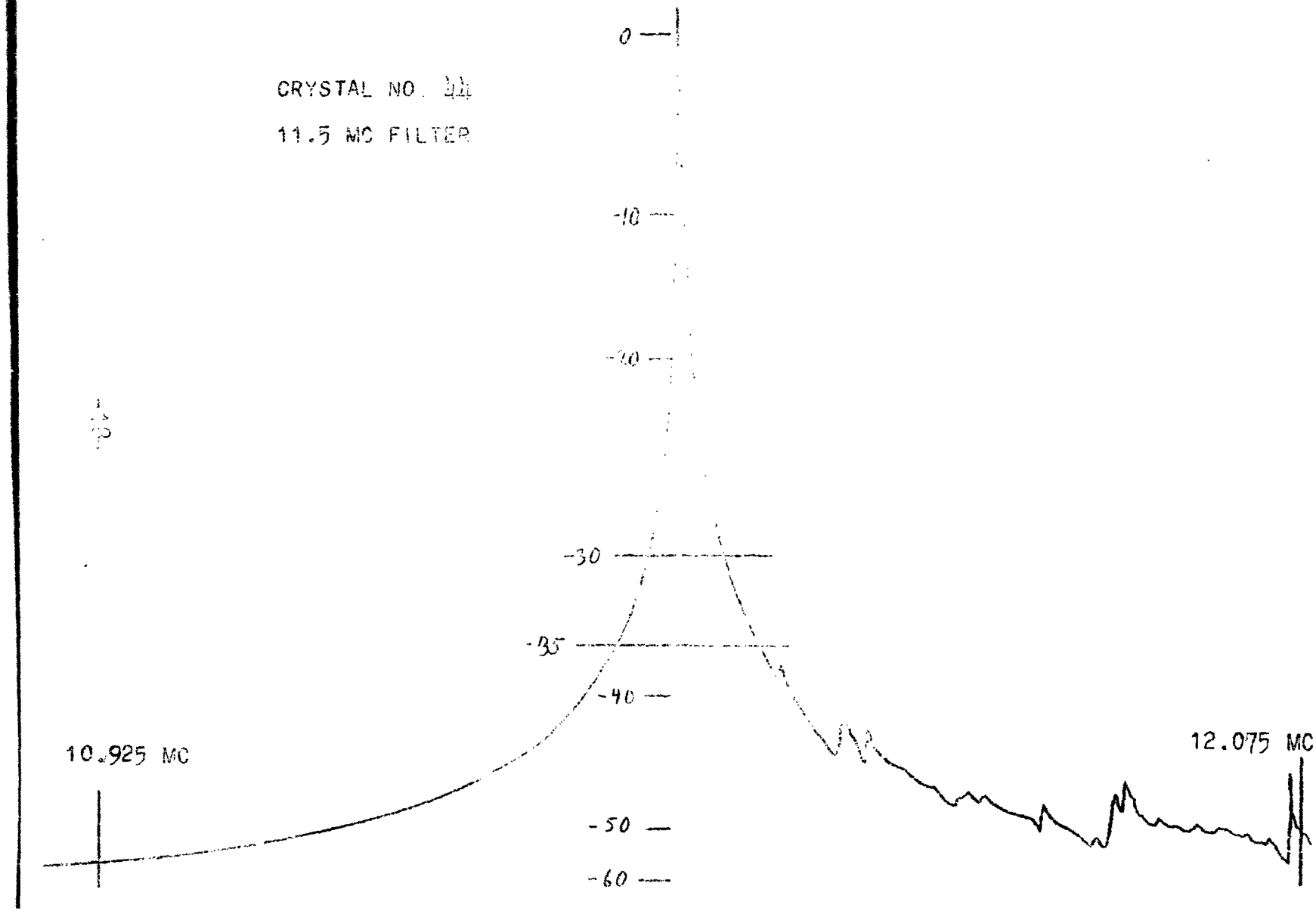
11.5 MC FILTER



CRYSTAL NO. 43

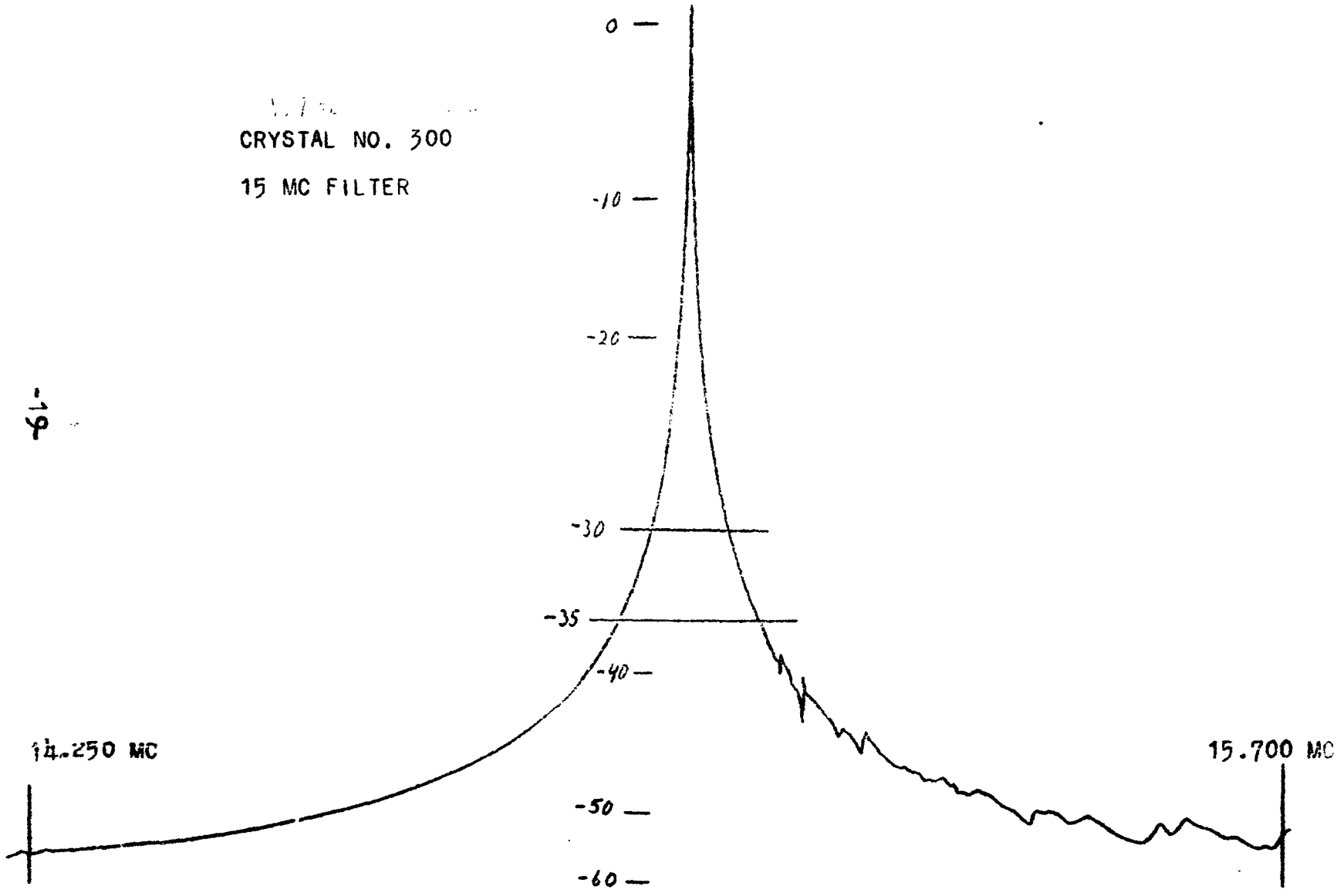
11.5 MC FILTER

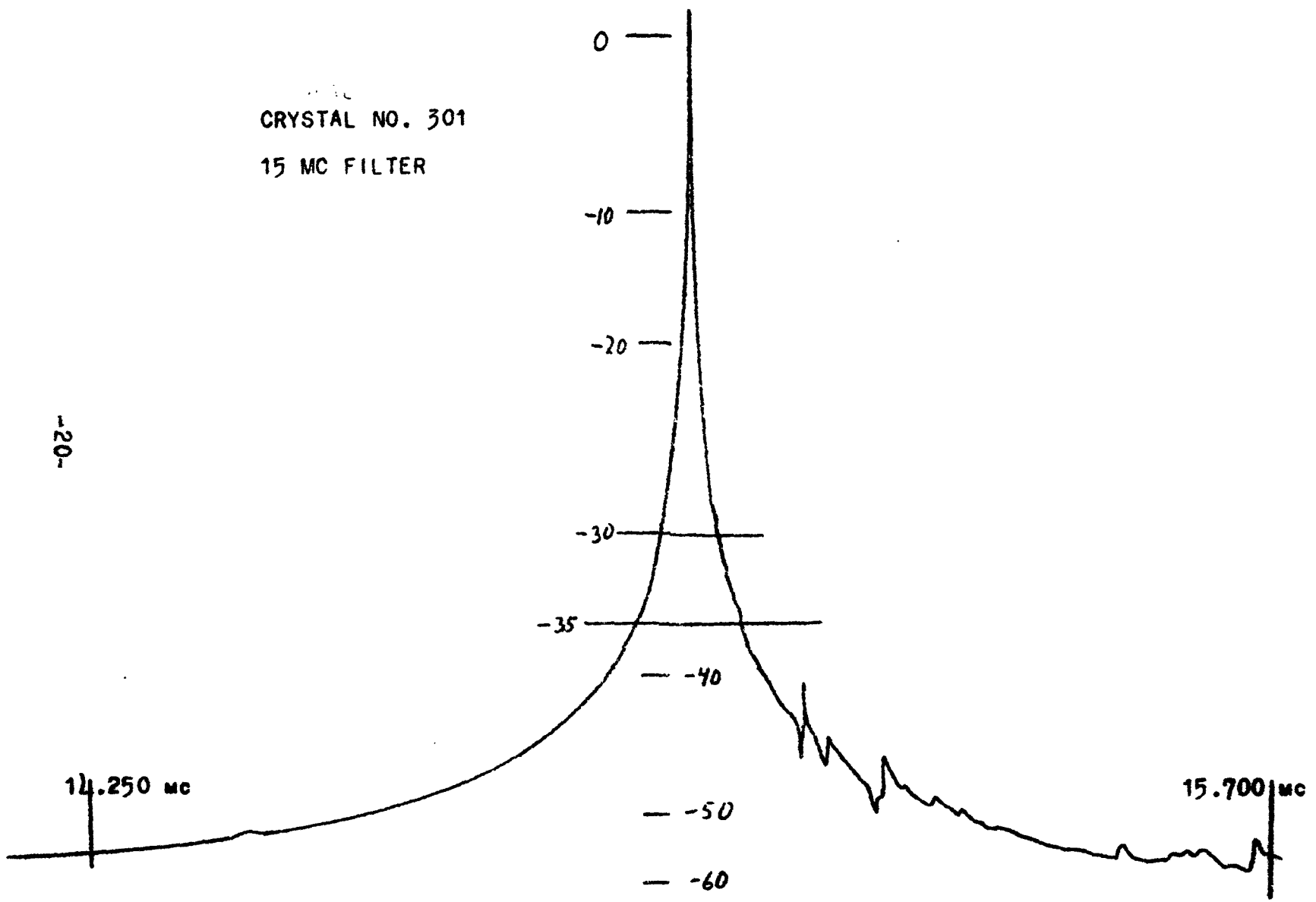


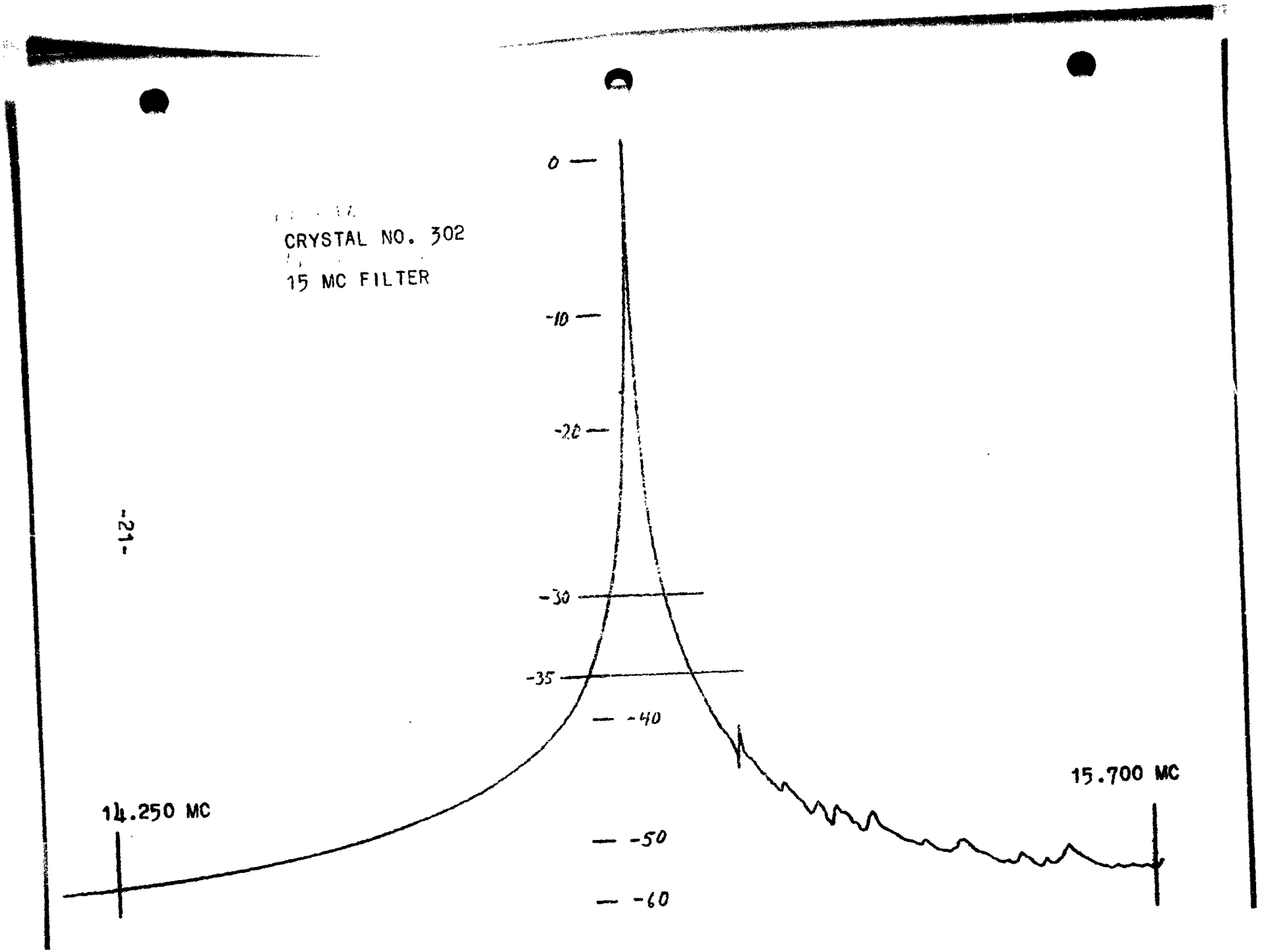

CRYSTAL NO. 44
11.5 MC FILTER
0
-10
-20
-30
-35
-40
-50
-60
10.925 MC
12.075 MC

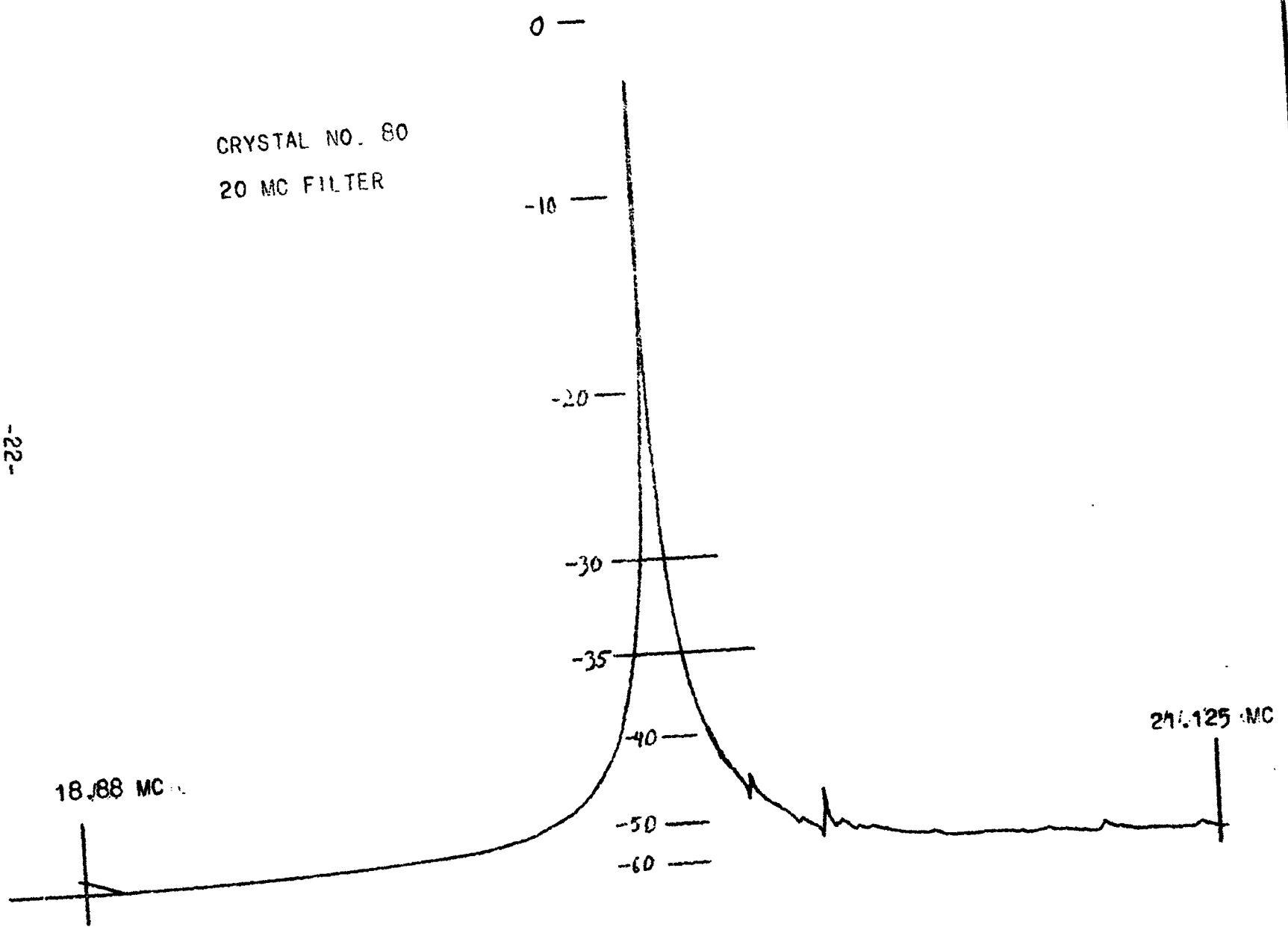
CRYSTAL NO. 300

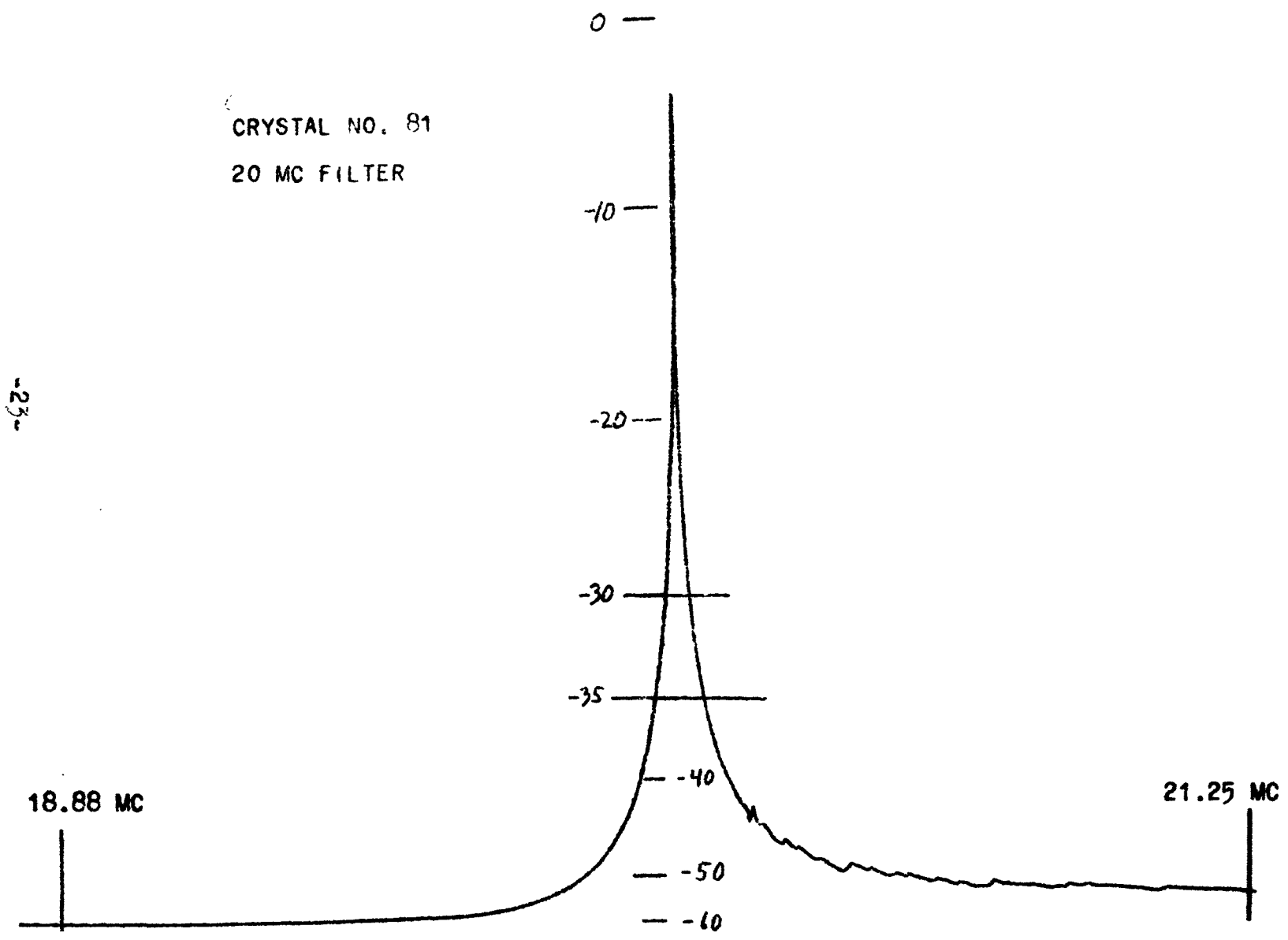
15 MC FILTER




CRYSTAL NO. 301
15 MC FILTER
0
-10
-20
-30
-35
-40
-50
-60
-20-
14.250 MC
15.700 MC

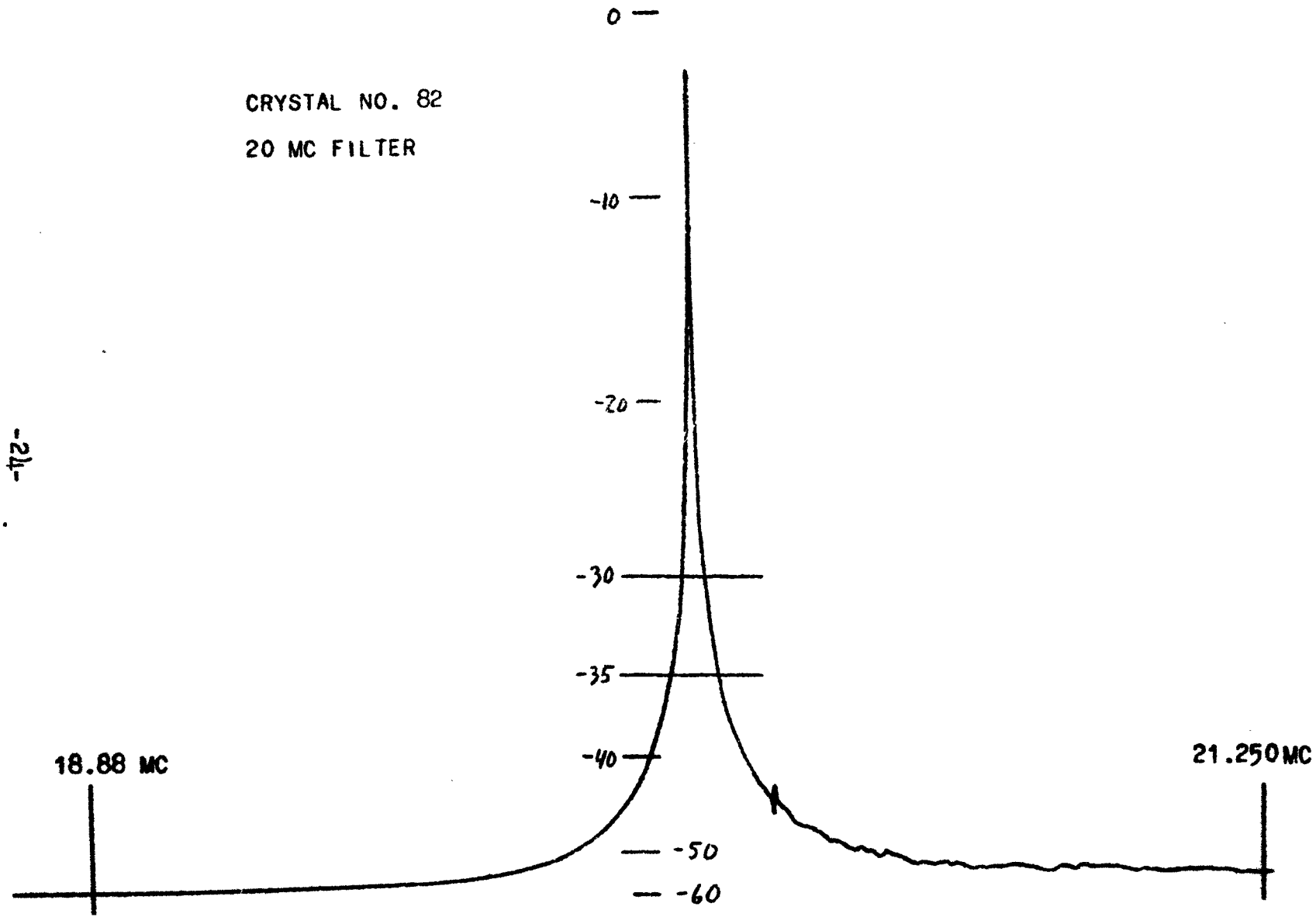

CRYSTAL NO. 302
15 MC FILTER
0
-10
-20
-30
-35
-40
-50
-60
14.250 MC
15.700 MC


CRYSTAL NO. 80
20 MC FILTER
0
-10
-20
-30
-35
-40
-50
-60
18.88 MC
21.125 MC


CRYSTAL NO. 81
20 MC FILTER
0
-10
-20
-30
-35
-40
-50
-60
18.88 MC
21.25 MC

CRYSTAL NO. 82

20 MC FILTER



CONCLUSIONS

CONSIDERING ALL THE PROBLEMS IN MANUFACTURING FILTER CRYSTALS WE FEEL CONFIDENT THAT FOLLOWING THE PRESCRIBED TECHNIQUES DEVELOPED DURING THIS CONTRACT, FILTER CRYSTALS CAN BE MANUFACTURED IN PRODUCTION QUANTITIES AND YIELDS.

SPURIOUS RESPONSES ARE ATTENUATED SUFFICIENTLY TO GIVE GOOD YIELDS, DUE PERHAPS TO CERTAIN CONTROLS ON SIZE & SHAPE OF THE BLANK AND FINISH.

SO FAR WE CAN ONLY INFLUENCE THE SPURIOUS RESPONSES BY ATTENTION TO MANUFACTURING BLANKS BY THE PRESCRIBED METHODS, WE DO NOT KNOW HOW TO ELIMINATE THEM.

PROGRAM FOR NEXT INTERVAL

MOST OF THE DEVELOPMENT ON MANUFACTURING OF FILTER CRYSTALS 10 MC TO 30 MC HAS BEEN DONE.

UPON APPROVAL OF OUR PREPRODUCTION SAMPLES WE WILL BEGIN PRODUCING THE BALANCE OF 500 UNITS ON EACH FREQUENCY.

PUBLICATIONS AND REPORTS

NO PUBLICATIONS OR REPORTS HAVE BEEN ISSUED ON THIS CONTRACT SINCE THE LAST REPORT FOR THE PERIOD ENDING August 9, 1962.

IDENTIFICATION OF PERSONNEL

OUR PERSONNEL WHO HAVE WORKED ON THIS PROJECT HAVE EXPENDED TIME AS FOLLOWS:

NAME	TIME-HOURS
DEEMER BLOSER	85
DONALD NEIDIG	25
CARRIE SHIERY	260
JUNE HOOK	75
MANUFACTURING LABOR	470